BRITISH STANDARD

BS EN
13364:2002

Natural stone test methods — Determination of the breaking load at dowel hole

The European Standard EN 13364:2001 has the status of a British Standard

ICS 91.100.15

National foreword

This British Standard is the official English language version of EN 13364:2001.

The UK participation in its preparation was entrusted to Technical Committee B/545, Natural stone, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English version

Natural stone test methods — Determination of the breaking load at dowel hole

Méthodes d'essai pour pierre naturelle — Détermination de l'effort de rupture au niveau du goujon de l'agrafe

Prüfung von Naturstein — Bestimmung der Ausbruchlast am Ankerdornloch

This European Standard was approved by CEN on 29 September 2001.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 246, Natural Stone, the Secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2002, and conflicting national standards shall be withdrawn at the latest by December 2002.

This European Standard is one of the series of standards for tests on natural stone.

Test methods for natural stone consist of the following parts:

EN 1925, *Natural stone test methods — Determination of water absorption coefficient by capillarity*.

EN 1926, *Natural stone test methods — Determination of compressive strength.*

EN 1936, *Natural stone test methods — Determination of real density and apparent density and of total open porosity.*

EN 12370, *Natural stone test methods — Determination of resistance to salt crystallization.*

EN 12372, *Natural stone test methods — Determination of flexural strength under concentrated load.*

EN 12407, *Natural stone test methods — Petrographic description.*

prEN 12371, *Natural stone test methods — Determination of frost resistance.*

prEN 13161, *Natural stone test methods — Determination of flexural strength under constant moment.*

prEN 13373, *Natural stone test methods — Determination of geometric characteristics on units.*

prEN 13755, *Natural stone test methods — Determination of water absorption at atmospheric pressure.*

prEN 13919, *Natural stone test methods — Determination of resistance to ageing by SO_2 action in the presence of humidity.*

prEN 14066, *Natural stone test methods — Determination of thermal shock resistance.*

prEN ....(WI 00246011), *Natural stone test methods — Determination of thermal dilatation coefficient.*

prEN ....(WI 00246012), *Natural stone test methods — Determination of sound — Speed propagation.*

prEN 14157, *Natural stone test methods — Determination of abrasion resistance.*

prEN 14205, *Natural stone test methods — Determination of Knoop hardness.*

prEN 14231, *Natural stone test methods — Determination of slip resistance by means of the pendulum tester.*

prEN ....(WI 00246018), *Natural stone test methods — Determination of static elastic modulus.*

prEN 14158, *Natural stone test methods — Determination of rupture energy.*

prEN 14147, *Natural stone test methods — Determination of resistance to ageing by salt mist.*

It is intended that other ENs should call up this EN 13364 as the basis of evaluation of conformity. (Nevertheless it is not intended that all natural stones products should be subjected regularly to all the listed tests. Specifications in other standards should call up only relevant test methods.)

This European Standard has an Annex A (normative).

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies a test method to determine the breaking load at the dowel hole of natural stones used for cladding or lining in building.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 10088-1, *Stainless steels — Part 1: List of stainless steels.*

EN 12390-4, *Testing hardened concrete — Part 4: Compressive strength — Specification for testing machines.*

EN 197-1, *Cement — Part 1: Composition, specifications and conformity criteria for common cements.*

3 Principle

This test consists of applying a force in a direction perpendicular to the face of a specimen through a dowel previously placed in an hole drilled in one of its sides and measuring the breaking load of the specimen.

4 Symbols

d is the thickness of the test specimen, in millimetres

d_1 is the distance from the hole wall to the face where fracture occurs, in millimetres

b_A is the maximum distance of the centre of the hole to the fracture edge on the face, in millimetres

F is the individual breaking load, in newtons

$\overline{d}_1$ is the mean value of d, in millimetres

$\overline{F}$ is the mean value of F, in newtons

$\overline{b}_A$ is the mean value of b_A, in millimetres

5 Apparatus

5.1 A balance capable of weighing the specimens with an accuracy of 0,01 % of their mass.

5.2 A ventilated oven capable of maintaining a temperature of (70 ± 5) °C.

5.3 A linear measuring device with an accuracy of 0,05 mm.

5.4 A rotary drilling machine equipped with a diamond or tungsten carbide tipped bit.

5.5 A testing machine of appropriate force in accordance with EN 12390-4 and calibrated according to this standard.

5.6 A clamping device consisting of two metal plates having the shape and sizes shown in Figure 1.

5.7 A device for applying loads perpendicular to the axis of the dowel (see Figure 2).

5.8 A room or chamber in which the temperature of the air can be maintained at (20 ± 5) °C.

6 Preparation of the specimens

6.1 Sampling and position of bedding

The sampling is not the responsibility of the test laboratory except where specially requested.

The position of any bedding or anisotropy shall be indicated on each specimen by means of at least two parallel lines.

6.2 Test specimens

6.2.1 General

The test can be carried out as an identification test or as a technological test.

Identification tests are tests carried out when the use of the stone with respect to the position of the planes of anisotropy and the thickness and surface finish of the elements in the cladding are not known.

Technological tests are those carried out when the use of the stone with respect to the position of the planes of anisotropy and the thickness and surface finish of the elements in the cladding are known. In this case the major faces of the specimens shall have the same orientation of the face that will be loaded during use.

6.2.2 Number of specimens

The minimum number of test specimens depends on the presence of planes of anisotropy.

If the stone does not show planes of anisotropy 10 tests of Type 0 (see Figure 3) shall be made on three specimens.

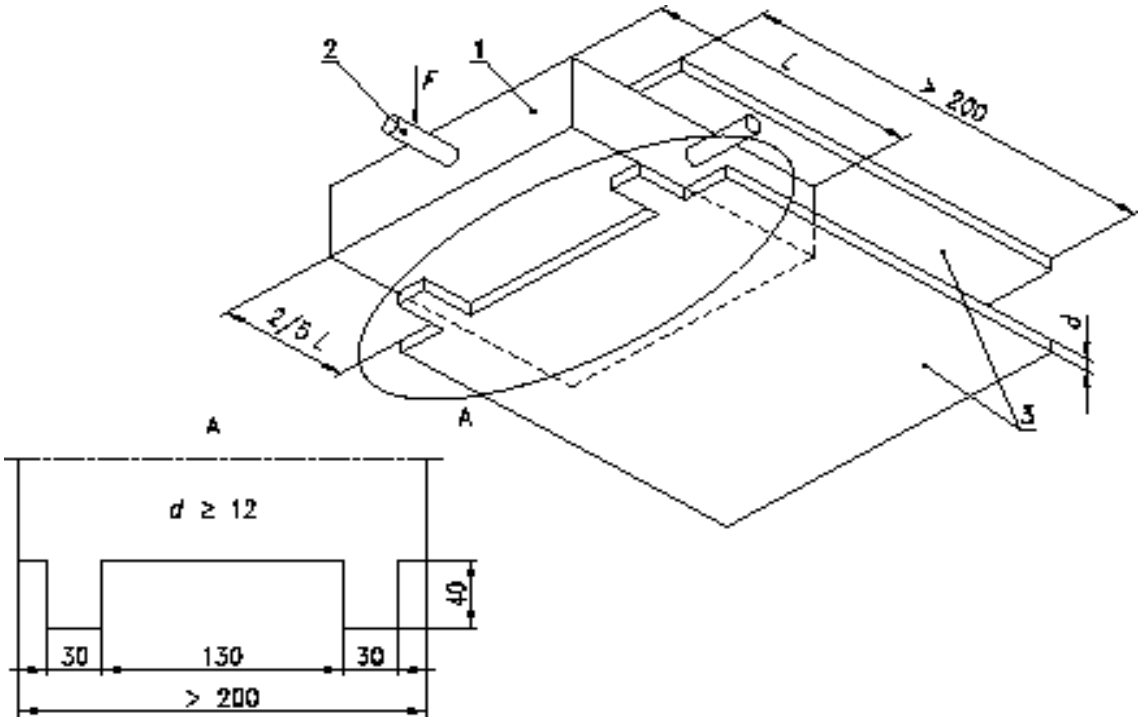
If the stone shows planes of anisotropy:

— 10 tests of Type I (see Figure 4) shall be made on three specimens cut parallel to the planes of anisotropy;

— 10 tests of Type IIa (see Figure 5) and 10 tests of Type IIb (see Figure 6) shall be made on five specimens cut perpendicular to the planes of anisotropy.

Dimensions in millimetres

a) General view



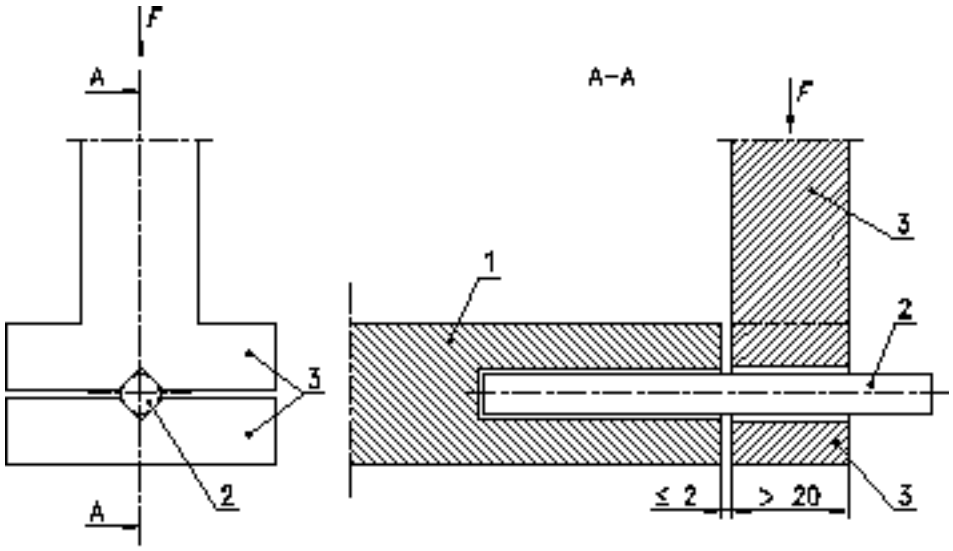
b) Detail of a plate suitable for tests on specimens having dimensions of 200 mm × 200 mm

Key

1 Specimen
2 Dowel
3 Metal plate
F Force applied on the specimen
L Length of the specimen
d Thickness of the metal plate

Figure 1 — Clamping device to hold the specimen in place

Dimensions in millimetres



Key

1 Specimen

2 Dowel

3 Device for applying load

F Force applied on the specimen

Figure 2 — Device for applying loads perpendicular to the axis of the dowel

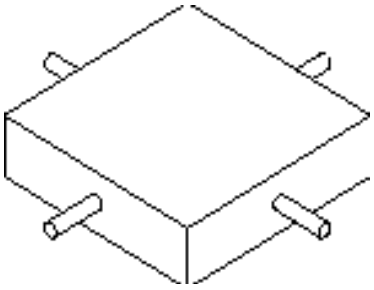


Figure 3 — Test arrangement for a specimen without planes of anisotropy (Type 0)

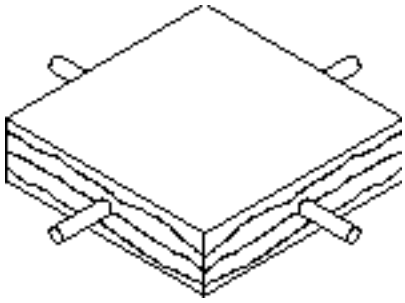


Figure 4 — Test arrangement for a specimen with the load applied perpendicular to the planes of anisotropy (Type I)

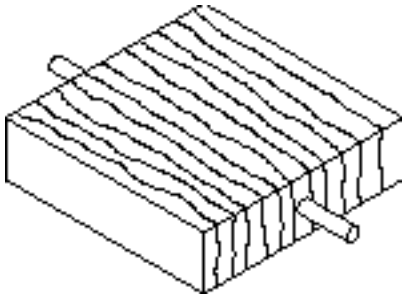


Figure 5 — Test arrangement for a specimen with the load applied parallel to the planes of anisotropy (Type IIa)

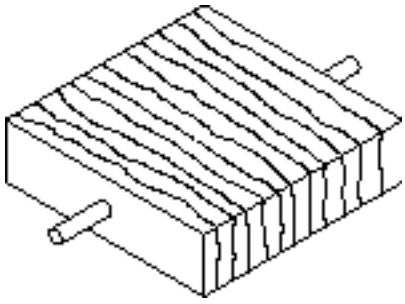


Figure 6 — Test arrangement for a specimen with the load applied parallel to the edges of the planes of anisotropy (Type IIb)

6.2.3 Surface finish of the specimens

a) Identification test

The surface finish on the faces and sides of the specimens shall be sawn, honed or polished.

b) Technological test

The surface finish on the faces and sides of the specimens shall be carried out according to the application (for example sawn, honed, polished, sanded, rubbed, flamed, bush-hammered, riven).

6.2.4 Dimensions of the specimens

a) Identification test

The specimens are square slabs with faces (200 ± 1) mm and a thickness of (30 ± 3) mm. The permissible deviation on the squareness is a maximum of 2 mm.

b) Technological test

The specimens are square slabs with the following dimensions:

Thickness	Dimensions
20 mm to 65 mm	200 mm × 200 mm
> 65 mm to 80 mm	300 mm × 300 mm

6.2.5 Location of the holes

a) Identification test

— The centre of the hole shall be situated between 98 mm and 102 mm from the other sides, measured to the nearest 0,5 mm.

— The thickness of stone between the edge of the hole and the two faces shall be (10 ± 2,0) mm, measured to the nearest 0,5 mm.

b) Technological test

— The centre of the hole shall be situated in the middle of the specimen's length.

— The thickness of stone between the edge of the hole and the face to be tested shall be according to the application, measured to the nearest 0,5 mm.

6.2.6 Dimensions and tolerances of the holes

a) Identification test

The diameter of the holes shall be (10 ± 0,5) mm. The depth of the holes shall be (30 ± 2) mm.

b) Technological test

The diameter of the holes shall be in accordance with the requirement of the application. The depth of the hole shall be (30 ± 2) mm.

6.2.7 Drilling the holes

The holes shall be wet drilled with a diamond or tungsten carbide tipped drill bit without hammering.

6.2.8 Planes of anisotropy

If the stone shows planes of anisotropy, the specimens are to be prepared in accordance with one of the arrangements shown in Figures 4, 5 and 6 and the position of the bedding or anisotropy is to be marked on the specimen by at least two parallel lines.

If the use of the stone with respect to the position of the planes of anisotropy is known, the test shall be carried out with the force applied on dowel placed in the hole in the side corresponding to the face that will be loaded during use.

If the use of the stone with respect to the position of the planes of anisotropy is not known or if more than one anisotropy is likely to be present, then the test shall be carried out in three perpendicular orientations and the total number of tests will be 30.

6.2.9 Conditioning

The specimens shall be dried to constant mass at (70 ± 5) °C in a ventilated oven after the drilling of the holes but before the dowels are fixed in place.

Constant mass is reached when the difference between two weighings carried out (24 ± 2) h apart is less than 0,1 % of the first of the two masses. After drying and prior to placing the dowels the specimens shall be stored at (20 ± 5) °C until the thermal equilibrium is reached.

6.2.10 Measuring d and d_1

After conditioning the thickness (d) and the distance from the edge of each hole to the lower face of the specimen in the direction of the force (d_1) shall be measured to the nearest 0,5 mm.

7 Dowels

7.1 Dimensions and tolerances

a) Identification test

The diameter of the dowels shall be (6,0 ± 0,1) mm. The length of the dowel shall be ≥ 50mm.

b) Technological test

The diameter of the dowels shall be in accordance with the required use. The length of the dowel shall be ≥ 50 mm

7.2 Material

The dowels shall be made of stainless steel Type 1.4571 according to EN 10 088-1.

7.3 Placing the dowels

Place one of the sides of each specimen in an upper horizontal position. Place the dowel vertically and centrally in the hole. Fix the dowel in the hole for a length of (25 ± 1) mm using mortar prepared with cement CEM I 52,5 R in accordance with EN 197-1 and a water/cement ratio of (0,6 ± 0,1) by mass.

Wait at least one hour and then repeat the same procedure for the other sides of the specimen that are to be tested (see Figures 3, 4, 5 and 6).

The specimens shall then be stored at (20 ± 5) °C for a minimum of 48 h prior to testing.

8 Test procedure

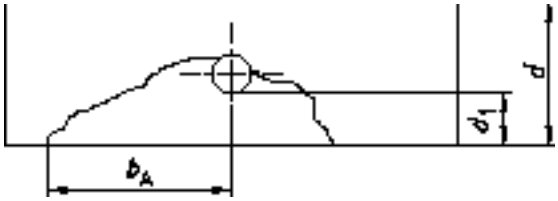
The specimen is clamped between the two metal plates of the clamping device on not more than 60 % of the specimen length (see Figure 1).

The load is exerted in a direction perpendicular to the axis of the dowel at a maximum distance of 2 mm from the edge of the specimen by means of the system shown in Figure 2.

The load is increased uniformly at a rate of (50 ± 5) N/s until the specimen breaks. The breaking load is recorded to the nearest 50 N.

If the dowel bends then the test shall be repeated with a larger diameter dowel and a new specimen.

After the specimen has failed the maximum distance from the centre of the hole to the fracture edge (b_A) shall be measured (Figure 7).



Key

d thickness of the test specimen

d_1 distance from the hole to the face in the direction of the force

b_A maximum distance of the centre of the hole to the fractures edge

Figure 7 — Dowel hole failure

9 Expression of the results

For each relevant direction of loading the following mean values shall be calculated from the individual results recorded for each test:

— the mean value of the distance from the hole to the face where the fracture occurs (d_1) expressed in millimetres to the nearest 1,0 mm;

— the mean value of the maximum distance from the centre of the hole to the edge of the fracture (b_A) expressed in millimetres to the nearest 1,0 mm;

— the mean value of the breaking load ($\overline{F}$) expressed in newtons to the nearest 50 N.

10 Test report

The test report shall contain the following information:

a) unique identification number for the report;

b) the number, title and date of issue of this European Standard;

c) the name and address of the test laboratory and the address of where the test was carried out if different from the test laboratory;

d) the name and address of the client;

e) it is the responsibility of the client to supply the following information:

— the petrographic name of the stone;

— the commercial name of the stone;

— the country and region of extraction;

— the name of the supplier;

— the direction of any existing plane of anisotropy (if relevant to the test) to be clearly indicated on the sample or on each specimen by means of two parallel lines;

— the name of the person or organization which carried out the sampling;

— the surface finish of the specimens (if relevant to the test);

f) the date of delivery of the samples or of the specimens;

g) the date when the specimens were prepared (if relevant) and the date of testing;

h) the number of specimens in the sample;

j) the results of measurements

— for each specimen:

— diameter of the hole;

— diameter of the dowel;

— dimensions of the specimen;

— thickness of the specimen;

— for each test:

— distance from the hole to the face in the direction of the force (d_1) in millimetres to the nearest 1,0 mm;

— maximum distance from the centre of the hole to the edge of the fracture (b_A) in millimetres to the nearest 1,0 mm;

— breaking load ($\overline{F}$) in newtons to the nearest 50 N;

— for each relevant direction of loading:

— the mean value $\overline{d_1}$ and the mean value $\overline{b}_A$ (in millimetres to the nearest 1,0 mm);

— the mean value of breaking load ($\overline{F}$) in newtons to the nearest 50 N;

k) all deviations from the standard and their justification;

l) remarks.

The test report shall contain the signature(s) and role(s) of those responsible(s) for the testing and the date of issue of the report. It shall also state that the report shall not be partially reproduced without written consent of the test laboratory.

Annex A
(normative)

Statistical evaluation of the test results

A.1 Scope

This annex establishes a method for the statistical treatment of test results obtained following the natural stone test method described in this standard.

A.2 Symbols and definitions

Measured values	$x_1, x_2, \ldots x_i, \quad x_n$
Number of measured values	n
Mean value	$\bar{x} = \frac{1}{n}\sum_i x_i$
Standard deviation	$s = \pm\sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$
Coefficient of variation	$v = \frac{s}{\bar{x}}$ (for individual values)
Logarithmic Mean	$\bar{x}_{ln} = \frac{1}{n}\sum_i ln\, x_i$
Logarithmic Standard deviation	$s_{ln} = \pm\sqrt{\frac{\sum (ln\, x_i - \bar{x}_{ln})^2}{n-1}}$
Maximum value	Max.
Minimum value	Min.
Lower expected value	$E = e^{\bar{x}_{ln} - k_s \cdot s_{ln}}$ where k_s (quantile factor) is given in Table A.1
Quantile factor	k_s see Table A.1

A.3 Statistical evaluation of test results

For the calculation of the mean value $(\bar{x})$, the standard deviation (s) and the coefficient of variation (v) a normal distribution is assumed.

For the calculation of the lower expected value (E) a logarithmic normal distribution is assumed. The lower expected value (E) corresponds to the 5 % quantile of a logarithmic normal distribution for a confidence level of 75 %.

Table A.1

Quantile factor (k_S) dependent on the number of measured values (n) in correspondence to the 5 % quantile for a confidence level of 75 %

n	k_S
3	3,15
4	2,68
5	2,46
6	2,34
7	2,25
8	2,19
9	2,14
10	2,10
15	1,99
20	1,93
30	1,87
40	1,83
50	1,81
8	1,64

The following examples should help to clarify the method:

Example 1:

Calculation of mean value, standard deviation, maximum value and minimum value of six measured values

Measurement no.	Measured value x
1	2 000
2	2 150
3	2 200
4	2 300
5	2 350
6	2 400
	—
Mean value	2 333
Standard deviation	147
Maximum value	2 400
Minimum value	2 000

Example 2:

Calculation of mean value, standard deviation, coefficient of variation and lower expected value of 10 measured values

Measurement no.	**Measured value x**	**($ln\ x$)**
1	2 000	(7,60)
2	2 150	(7,67)
3	2 200	(7,70)
4	2 300	(7,74)
5	2 350	(7,76)
6	2 400	(7,78)
7	2 600	(7,86)
8	2 750	(7,92)
9	2 900	(7,97)
10	3 150	(8,06)
	—	—
Mean value	2 480	(7,807)
Standard deviation	363	(0,143)
Variation coefficient	0,15	

From Table 1 for: n = 10 k_S = 2,1

Lower expected value 1 819

Bibliography

EN 12440, *Natural stone — Denomination criteria.*

prEN 12670, *Natural stone — Terminology*.

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